United States
Department of
Agriculture

Science and
Education

Energy Capabilities and Opportunities

Preface

Energy is essential for all components of the food and fiber system--production, processing, transportation, and final preparation--and for comfortable rural living. The Science and Education Administration (SEA), part of the U.S. Department of Agriculture (USDA), conducts and supports research to find solutions to priority food, agriculture, family living, and community problems facing rural America and the Nation and provides information to farmers and consumers through the Cooperative Extension Service in each State. SEA, through its Office of Higher Education, also represents teaching interests of the USDA. These functions are carried out through the land-grant-university system, which includes the State Agricultural Experiment Stations and the Cooperative Extension Services, and through in-house Research and Extension at the Federal level. An additional component of SEA is Technical Information Systems (TIS). The TIS program provides for the operation and continuing development of a comprehensive and coordinated information system, including the National Agricultural Library.

Growing energy costs and the possibility of sporadic shortages dictate the placing of much greater emphasis on energy implications in SEA's teaching, research, and Extension programs to ensure a continued, adequate supply of food and fiber to all consumers at reasonable prices and to ensure a satisfying lifestyle for rural living. The preparation of this document was the first step in the development of a comprehensive plan for SEA to:

- Assure that the food and fiber system and rural households and communities use energy efficiently and conserve energy resources whenever feasible.
- Assure that agriculture produces energy (biomass fuels) in a manner that does not adversely affect food supplies or land resources.
- Provide a document for use by administrators in policy development, budgeting, and coordination with other agencies and groups.

A task force was appointed and charged with the responsibility of reviewing teaching, research, and Extension needs relative to energy and agriculture and of developing this document--a statement of SEA's energy capabilities and opportunities. Members included energy specialists, SEA staff persons, and agricultural administrators. Bill A. Stout, Energy Specialist at Michigan State University, served as chairman. The task force members were:

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Warren Doolittle, Forest Service
Gene McMurtry, Extension Committee on Policy
Lamar Harris, Experiment Station Committee on Policy
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C. A. Pettibone, Resident Instruction Committee on Policy

To help implement the findings of the task force, a working group of SEA staff persons has been appointed to develop a Strategic Energy Plan for SEA (first draft prepared). The Strategic Plan will provide a concise statement of goals, strategies, objectives and approaches for the energy research, Extension, and education programs of SEA and its cooperators and will include 6-year technology and resource projections. It will also describe the implementation strategies and policy structure required to effectively initiate and monitor these programs.

SEA units have started to develop Operational Energy Plans to define specific program elements and projects, operating procedures, and short-term resource projections. The scientific community will play a significant role in the development and implementation of Operational Energy Plans.

The task force found that the agricultural system, with SEA playing a lead role, is highly qualified to carry out research, demonstration, and education programs relative to the production of renewable energy supplies from agricultural sources and to the efficient use of energy in agriculture, family living, and rural communities. However, SEA's teaching, research, and Extension programs will require significantly increased funding to carry out the urgently needed energy work.

The United States is the recognized world leader in agriculture. Inadequate or temporarily interrupted energy supplies threaten the continuing capacity of U.S. agriculture to provide adequate food and fiber at reasonable prices. This productive capacity is important in maintaining the standard of living presently enjoyed by all Americans. I hope we can find ways to fund and to implement the needed research and educational programs described herein and, thus, to minimize the negative effects of petroleum shortages and costs on our Nation's production of food and fiber.

A reorganization of the Science and Education Administration was announced on June 17, 1981 and four new program agencies were created: the Agricultural Research Service, the Cooperative State Research Service, the Extension Service, and the National Agricultural Library. This report was ready for publication when the reorganization was announced. Rather than revise the report to conform to the new organizational structure, it is published as an administrative report for use of USDA agencies and cooperators.

Anson R. Bertrand

Anson R. Bertrand, Director
Science and Education
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SUMMARY

CURRENT SITUATION

The present energy situation threatens world peace, leads to strained relationships between our Nation and some of our allies, and diminishes hope for a better standard of living for many people throughout the world. To cope with these problems we must use energy more efficiently, reduce waste, and produce alternative fuels from renewable sources on farms and forestlands.

While the U.S. food system is very progressive and highly productive, it is also energy intensive. It uses about 16.5 percent of the Nation's energy—2.9 percent in production agriculture, 4.8 percent in processing, 1.7 percent in distribution and transportation, and 7.1 percent in preparation, consumption, and rural living.

Agriculture is being asked to produce more commodities, not only for domestic and foreign food, but for conversion to alternative fuels. An extensive teaching, research, and Extension system is in place and thousands of highly trained agriculturists are already at work. However, energy is a new mission for agriculture and energy production problems will require greatly expanded research and education programs.

NEEDS, OPPORTUNITIES, AND IMPACTS

The goals of the USDA/SEA energy program are to increase energy-use efficiency in the U.S. agriculture system, to develop agricultural energy supplies without adversely affecting soil resources and the environment, and to increase agricultural production to contribute to U.S. energy independence.

An assured supply of energy for the U.S. food and agricultural system is clearly in the national interest. The publicly supported agricultural teaching, research, and Extension system should develop and publicize its energy programs to facilitate understanding of the issues and to generate support for them. This plan addresses the need for training of professionals to meet energy program needs; establishment of a comprehensive data base on energy use in the food system and rural America; identification of energy conservation opportunities for rural homes and communities and for production, processing, transportation, and storage of agricultural products; development of renewable energy technologies for use on farms, in rural households, and in communities; and improvement of the technology transfer system.

PROGRAMS AND PRIORITIES

Recommended programs include efficient energy management and conservation in production agriculture, in processing and distribution, in family living and housing, and in communities; development of alternative energy sources such as biomass fuels and solar and wind energy; and development of integrated agricultural energy systems. Important objectives and criteria for setting priorities and for allocation of funds are discussed.

RESEARCH AND EXTENSION SYSTEM

Agricultural research functions of Federal and State entities are coordinated through Federal-State partnership created by the Hatch Act. The Cooperative Extension System is a three-way partnership of Federal, State, and county entities created by the Smith-Lever Act. In addition, user advisory groups function at various levels to assist with developing and implementing of plans and with resolving problems. Agricultural energy programs are coordinated with other agencies at the national level through the Special Programs unit of SEA. This system has enabled U.S. agriculture to be very progressive and very productive. Energy is a new mission, but the same systems that have been so successful for agriculture can focus on, and solve, agricultural energy problems.

RESOURCES

Production agriculture uses about 2.9 percent or 800,000 barrels of oil per day (an amount equal to approximately one-tenth of U.S. imports in 1979). Based on the current price of imported oil, liquid fuel for production agriculture each year has a value of about $9 billion (or $25 million per day). If one percent of this value for liquid fuel were designated for research and education, $90 million per year would be available--a small amount considering the needs for and benefit of energy independence.

However, the entire food system uses about 16.5 percent of the Nation's energy and by the same logic as above, 1 percent of the value of energy for the entire food system is approximately $500 million. Designation of such levels of support would ensure the development of technologies to enable one grower to produce food for at least 73 other Americans, in addition to that produced for export. The whole food chain from production to consumption would become more efficient.

The Task Force recommends that $107 million per year be dedicated to agricultural energy programs for 1981-85, $179 million for 1986-90, and $280 million for 1990-2000. SEA's budget for energy programs in FY 1980 was $28.8 million, plus an additional $4.4 million passed through from the Department of Energy and the Environmental Protection Agency.

EVALUATION

Evaluation is critical to program management. A system for determining the progress of energy research programs on a timely basis is needed. User activity, response, or investment resulting from Extension programs need to be evaluated. Accomplishments in each category of research and technology transfer should be clearly measured and documented.

Energy Capabilities and Opportunities

I. CURRENT SITUATION

Agriculture and rural America are on the threshold of a new era that promises to be as challenging and exciting as any in past history. America's astounding productivity of food and fiber has earned for agriculture the reputation of being its most progressive industry. The agricultural system is now being asked to provide not only more food and fiber, but also substantial quantities of liquid and gaseous fuels to meet U.S. energy demands. The research and educational requirements to meet these demands must be financially supported, or the expected results--so essential to the future welfare of many countries--may not be accomplished.

The maintenance of agricultural productivity at a level sufficient to avoid major food shortages will require continued use of modern food system technologies. An adequate supply of liquid fuels and electricity will be essential. Figure 1 shows major energy use categories; the shaded portions represent energy use in the U.S. food system. Liquid fuel availability and cost are of immediate concern to the United States, because large amounts of petroleum are imported. In addition, the rapid depletion of existing natural gas reserves, coupled with deregulation, has increased speculation that the price for natural gas will soon reach levels comparable to those for other fuels.

The present energy situation threatens world peace, leads to strained relationships with some U.S. allies, and diminishes hope for a better standard of living for many people throughout the world. To cope with these problems, we must share limited petroleum and natural gas resources worldwide, use energy efficiently and reduce waste throughout all sectors in rural America, produce energy from renewable resources on farms and forestlands, and use alternatives to petroleum and natural gas. By producing energy from renewable resources while implementing major energy management and conservation practices, the rural sector can contribute greatly toward solutions to our Nation's energy problem.

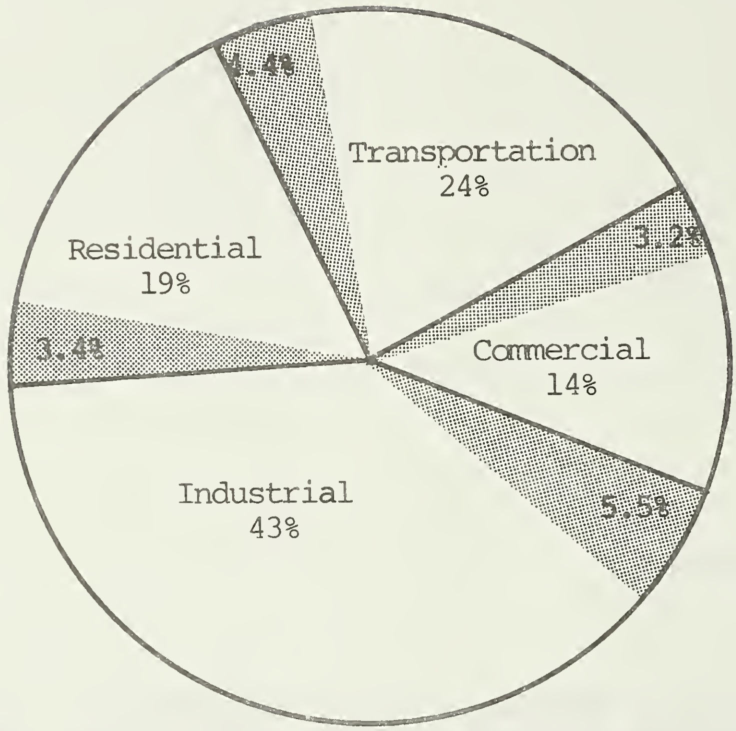

Figure 1. Major categories of energy use in the United States. The shaded portion represents the energy consumption (16.5 percent) by the U.S. food system. (Energy Use in the Food System, Federal Energy Administration, Report No. 13392-007-001, May 1976).

FOOD, FIBER, AND ENERGY PRODUCTS

Although on-farm production uses less than 3 percent of the total U.S. energy consumption, prompt delivery and timely use of fuel is critical for most farm operations. A shortage of fuel that delays planting or harvesting can significantly reduce the quality or quantity of food available for domestic use and export. The total food system from the farm to the kitchen table uses about 16.5 percent of the Nation's energy (Table 1).

The increasingly high cost of imported petroleum is hindering some developing countries from improving their food productivity. Food-deficient countries expect that the United States will continue to supply them with adequate quantities of food and feed grains. The extent to which these grain supplies depend on adequate supplies of energy for U.S. farmers is not fully appreciated, either at home or abroad. Any diversion of normally exported grains to the production of alcohol fuel to help meet the energy needs of farmers and others in our own Nation must be evaluated in terms of the impact on the food needs of the importing countries. Some of the effects of a decrease in grain exports might be offset by increased export of food proteins formed as byproducts of the grain-to-alcohol conversion.

Table 1. Distribution of energy use in U.S. food system 1/

Activity	% of U.S. energy
Production	2.9
Processing	4.8
Distribution	1.3
Consumption and preparation:	
Out-of-home	2.8
In-home	4.3
Transportation across the system	0.4
Total	16.5

1/ Energy Use in the Food System, Federal Energy Administration, Report No. 13392-007-001, May 1976.

RURAL COMMUNITY SECTOR

Significant impacts can be made on the economic, social, and environmental conditions of rural communities and their people through reduction in the energy used both directly and indirectly by the communities. People in a community can utilize known energy resources more effectively and extend limited supplies of natural gas and petroleum by evaluating the energy impacts of economic development, capacity building, community facilities and services, recreation, transportation, housing, and land use. As rural communities address energy policies, community-based organizations and Federal, State, and local governmental agencies need to share information and develop appropriate solutions to meet specific needs.

Families living in rural areas often require more energy than their urban counterparts. The rural residential sector uses about 4 percent of the U.S. energy consumption directly and a much larger amount indirectly. The percentage of old, energy-inefficient housing is higher in rural than in urban areas. The farm home is usually the center of farm management operations, and frequent trips in and out of the house increase the energy required for maintaining a comfortable temperature, for routine cleaning, and for replacement of home furnishings. In addition, rural families often must provide their own water supply and drive many miles for shopping, community activities, services, or emergency repairs on farm equipment. Most rural residents lack easy access to public transportation. Rural families use additional energy for growing and preserving much of their own food. Laundry needs are considerable because family members work in adverse weather conditions, handle fertilizers and insecticides, and work with livestock, and soil, odors, and pesticide residues must be removed.

THE RESEARCH AND EXTENSION SYSTEM

Research and Extension efforts by the public sector in agriculture have provided many benefits. Plentiful supplies of food and fiber have been available at more reasonable prices than anywhere else in the world. Food product quality has continually improved through effective agricultural research and information transfer programs. Residual effects of research and Extension programs can provide years of benefits to the rural sectors and also contribute to the growth of cities and the Nation.

Teams of specialists representing several disciplines are necessary to ensure that solutions are socially, economically, and environmentally acceptable. Regional demographic, climatic, and natural resource differences must also be considered. These research efforts require long-term continuity. The expertise to conduct effective teaching, research, and Extension programs is available throughout the publicly supported agricultural research and Cooperative Extension System (CES).1/ Laboratory facilities, research equipment, and testing apparatus are available in the Science and Education Administration (SEA) system. As projects are successfully concluded, the resources applied to that research become available to address other urgent problems. The interconnection of research with Extension and teaching disciplines in the SEA system provides swift and efficient transition from research to practical application. However, some research and Extension efforts currently depend on DOE for funding, and the development and maintenance of comprehensive long-term agricultural energy programs are difficult.

Research

A major reason for the success of publicly supported agricultural research efforts is the wide range of skills, high degree of excellence, and extensive facilities that are available within the combined structure of SEA, the State Agricultural Experiment Stations (SAES), and the nonland-grant institutions. Historically, SEA and the SAES have pooled ideas, manpower, and facilities in coordinated attacks on problems that have been common to several States, a region, and even the entire Nation. The total research effort within this system is equivalent to more than 11,000 full-time scientists (Table 2). Each of the State institutions has extensive laboratory and field testing facilities. In addition, Agricultural Research (AR) has 150 Federal laboratories and accompanying experimental, field testing facilities. Several of these State and Federal facilities are focusing on solutions to energy problems. With additional resources, more rapid progress could be made in resolving critical energy problems. A substantial benefit integral to the USDA energy program is the training that comes from involving students in Federal and State research laboratories.

1/ Definitions of the abbreviations used herein are listed at the end of the document.

Table 2. Agricultural research personnel

Performing or supporting agency	Scientist-Years (FY 1978)
NASULGC:1/	
56 State Agricultural Experiment Stations	6,574
16 Colleges of 1890 and the Tuskegee Institute	152
19 Forestry schools	209
NASULGC Total	6,935
USDA:	
Science and Education Administration	3,010
Economics and Statistics Service	474
Forest Service	970
USDA Total	4,454
Grand Total	11,389

1/ National Association of State Universities and Land Grant Colleges.

Extension

The Cooperative Extension Service in each State provides education and technology transfer to users. The most important key to the success of the agricultural technology transfer program is the unique Cooperative Extension System in which Federal, State, and county governments form a three-way education partnership. This partnership has its roots in more than 3,000 county Extension offices close to the technology users. County Extension agents have direct access to researchers and are supported by highly skilled specialists at the State and Federal levels. These State and Federal specialists follow evolving and new national and international developments within their areas of specialization, synthesize these technologies into practical systems, and work with county Extension agents in developing training programs and providing specific counsel to users of the technological developments. Of the nearly 17,500 professionals in Extension, 3,371 are full-time equivalent specialists at the State level. The total number of individuals is somewhat greater, as part of the time of some specialists is devoted to other activities—often research.

The Extension program is greatly bolstered by volunteers. A recent inventory revealed that there were about 380,000 members of councils, boards, and committees participated in planning and conducting programs. Nearly 580,000 volunteer leaders teach and work with more than 5 million youths in the 4-H program.

Education and technology transfer within Extension is further augmented by experienced information specialists and an extensive communications system that reaches users through use of mass media such as television, radio, newspapers, and magazines. These specialists work closely with researchers and Extension specialists in developing news releases and in making presentations on television and radio. Of even more lasting significance is the involvement of the researchers and Extension specialists in preparing hundreds of widely distributed popular publications and in conducting public workshops, seminars, conferences, and short courses.

THE BASE PROGRAM FOR ENERGY RESEARCH AND EXTENSION IN SEA

The energy research and Extension programs conducted in FY 1980 are discussed below. Table 3 is a summary of funding for programs by objective and responsible SEA unit, including State funding and pass-through funds from the Department of Energy (DOE) and the Environmental Protection Agency (EPA).

SEA established two agricultural energy centers in FY 1980 to be focal points for research, development, and technology transfer programs for alternative energy sources. The centers operate through the Assistant Director of Special Programs; AR, CR, and EXT have program responsibility, and AR provides administrative management. The Southern Agricultural Energy Center (SAEC) at Tifton, Georgia, is responsible for the development of on-farm energy systems, and the Northern Agricultural Energy Center (NAEC) at Peoria, Illinois, is responsible for the production and conversion of biomass as an energy source.

A recently published inventory of energy research and technology transfer programs[2/] classified activities into three main objectives or groups: substitution of renewable or noncritical energy sources and forms; energy conservation; and consequences of energy production, availability, and use. Brief narrative descriptions of the FY 1980 research and Extension programs included in each group follow.

Research Programs in FY 1980

Substitution of Renewable or Noncritical Energy Sources and Forms

Agricultural applications of solar energy.-DOE and its predecessor, the Energy Research and Development Administration (ERDA), have provided funds to SEA since 1975. About 50 projects have been competitively selected each year to complement in-house research on solar crop drying, food processing, and building heating. The program is now managed by the SAEC.

2/ Inventory of Agricultural Energy Research and Development and Technology Transfer for FY 1977. A joint study conducted by the National Association of State Universities and Land Grant Colleges and the USDA, September, 1978.

Table 3. Summary of funding for energy programs by objective and SEA unit--FY 1980

Objective	Responsible SEA unit	SEA	State and other	DOE	Total
		--------thousands	of dollars--------		
Substitution of renewable or noncritical energy sources and forms:					
Solar energy at SAEC	AR	950	—	2,100	3,050
Wind energy	AR	250	—	468	718
Agricultural biomass	AR	4,600	—	—	4,600
Agricultural biomass	EXT	500	625	—	1,125
Solar energy	EXT	600	750	1,150	2,500
Wind energy	EXT	300	375	—	675
Production and marketing of alcohols	CR	500	—	—	500
Special energy grants	CR	1,900	—	—	1,900
McIntire-Stennis forestry research	CR	200	1,000	--	1,200
Subtotal		9,800	2,750	3,718	16,268
Conservation and use of energy:					
Energy aspects of other research	[AR	8,200	—	—	8,200
	[CR	700	3,500	—	4,200
Family living	EXT	3,200	4,000	—	7,200
Agricultural systems	EXT	3,900	5,875	—	9,775
Natural resources (biomass)	EXT	500	625	--	1,125
Subtotal		16,500	14,000	—	30,500
Consequences of energy production, availability, and use	[AR	1,000	—	700 1/	1,700
	[CR	500	2,500	—	3,000
	[EXT	1,000	1,250	--	2,250
Subtotal		2,500	3,750	700	6,950
Grand Total		28,800	20,500	4,418	53,718

Summary of SEA funding by units ($000):AR, 15,000; CR, 3,800; EXT, 10,000.

1/ Includes $0.4 million in EPA pass-through funds for mined-land reclamation.

Wind energy for farm and remote applications.-Since 1976, DOE and ERDA have supported research on wind systems for irrigation, environmental control, and other applications. Management of this program was transferred in April 1980 from Beltsville to Bushland, Texas, a satellite location of SAEC. SEA base funds have also been used for in-house research on wind energy.

Agricultural biomass.-The AR program includes research on producing, harvesting, collecting, and converting of energy crops, on handling and feeding of stillage produced in converting corn into fuel alcohol; on generation of methane from animal wastes; on increasing the efficiency of alcohol fermentation processes; on selection, screening, and genetic improvement of crops for alcohol production; on identification and evaluation of hydrocarbon-producing plant species that are adaptable to U.S. agricultural practices; and on small-scale energy systems. The research is managed by the regional agricultural energy centers. SEA-Extension manages on-farm methane demonstrations cooperatively with several States.

Energy needs are being determined for specific tasks in various agricultural enterprises. The data will serve as a base from which to design electrical vehicles for a broad range of tasks. The inefficient pickup truck is a prime candidate for replacement by electric or electric-hybrid vehicles.

Production and marketing of alcohols and industrial hydrocarbons.-This program of university grants was initiated in 1979 at the level of $500,000 to support competitively selected research projects on the development of new, efficient strains of ethanol fermentation organisms and on improvement in the tolerance of the organisms to the alcohol product. Also included were continuous fermentation, staged substrate feeding, improvement of distillation and dehydration, membrane and phase separations of the alcohol, and precipitation and collection of stillage protein. Two research projects in small-scale, on-farm alcohol production systems were included in FY 1980.

Energy grants.-Research was supported under the CR program of "Special Grants" in the amount of $1.9 million. Grants were awarded on fermentation processes for alcohols other than ethanol and for hydrocarbons and oils. Thermal processing research for conversion of biomass included work on gasification, liquid synfuels, pyrolysis oils, engine testing of fuels, and direct combustion of biomass materials. Energy conservation and the development of solar and wind energy were included. Research was also included on biomass screening to choose high-production varieties and species and to develop production, collection, and storage methods.

McIntire-Stennis forestry research.-The McIntire-Stennis Forestry Research Program, under the auspices of CR, supported energy research at universities in the amount of $200,000 on wood fuel resources, woodlots, harvesting methods, gasification, pyrolysis, and the production of chemicals from wood. These universities also are investigating the economics and investment problems of large-scale forest energy plantations.

Energy Conservation

Research in energy conservation is generally conducted as a component of projects that included other objectives. In 1977, 422 projects of this type in AR and the SAES were identified in an "Inventory of Agricultural Energy Research and Development and Technology Transfer." Projects to reduce energy consumption in crop production include fertilizer-use efficiency, irrigation efficiency, more efficient tillage machines and systems, and minimum tillage. Crop processing projects include grain drying, extracting edible oils, and refrigerating perishable commodities. The Federal funding of the energy component of these research projects amounted to $8.9 million in FY 1980.

Consequences of Energy Production and Use

Programs in this area consist of mined-land reclamation, assessment of water and air pollution resulting from mining and fuel use, and effects on the environment of removing crop residues for energy. AR received $400,000 from EPA and $300,000 from DOE to augment about $1 million of in-house research funds. CR also directly supported $500,000 of research and completed a 5-year program of reclamation grants funded by EPA. Final reports on 57 projects are now being published.

Extension Programs in FY 1980

Substitution of Renewable or Noncritical Energy Sources and Forms

Solar heating demonstrations.-Extension has established about 90 demonstration projects on the use of solar heating in livestock production. These demonstrations are conducted on farms in nine States and involve swine, poultry, and dairy operations. The nine participating States contribute resources to these programs. A similar program was initiated for solar grain drying in FY 1980. DOE funding for solar programs was $1.15 million.

Alternative sources.-Almost every State Cooperative Extension Service is conducting programs in alcohol, in wood and other biomass crop production, and in the use of alternative energy sources, such as solar and wind. These programs provide information on such things as application feasibility, construction details, and community and legal aspects of using alternative energy. The current funding level is about $1 million of Smith-Lever funds redirected from other programs.

Energy Conservation

Energy conservation in agricultural production.-Extension conducts a wide range of activities designed to reduce energy consumption in agricultural production. These activities consist of programs in farm equipment selection, maintenance and operation; irrigation scheduling; minimum and no tillage; fertilizer use and placement; and insulation and ventilation control of livestock shelters. Federal support of energy conservation education programs was about $3.9 million.

Energy conservation in family living and the community.-Extension programs are conducted in energy conservation for the family at home and for the community.[3/] These programs include home weatherization; space utilization; home management with reduced energy usage; clothing; home furnishings; food preparation and preservation; youth programs in energy conservation; community action for energy management; renewable resources; and transportation. Federal support for these programs was about $3.2 million.

Energy conservation in renewable natural resources.-This program is centered on the conservation of energy in the production and use of wood as an alternative source of energy and on the use of wood byproducts as energy for the wood industry. Federal support for this program was about $500,000.

ENERGY LEGISLATION AFFECTING USDA

The Food and Agriculture Act of 1977, P.L. 95-113 (commonly called the 1977 Farm Bill), authorized USDA to engage in energy research and development under Title XIV, Subtitles C and H. Subsection 1419 of Subtitle C provided for research on the production and marketing of alcohols and industrial hydrocarbons from agricultural commodities and forest products and on agricultural chemicals and other products from coal derivatives. Subtitle H provided for solar energy research and development, model farms and demonstration projects, and regional solar energy research and development centers. Research and demonstration projects are underway.

The Energy Security Act of 1980, P.L. 96-294 (commonly called the Synfuels Bill), became law on June 30, 1980. Title II of the Synfuels Bill is titled "The Biomass Energy and Alcohol Fuels Act of 1980." Subtitle A provided for general biomass energy development and established the Office of Alcohol Fuels in DOE. Subtitle C provided for biomass energy research and demonstration projects and for establishment of not more than 10 model demonstration biomass energy facilities for exhibiting the most advanced technology available for producing biomass energy.

In addition to the biomass energy research, Extension, and demonstration programs that are summarized in Table 4, the Synfuels Bill also authorized

- Financial assistance for small-scale biomass energy.

- Cost sharing for energy conservation practices in agricultural production.

- Use of timber resources of the National Forest System for biomass energy products.

3/ "A Comprehensive National Plan for New Initiatives in Home Economics Research, Extension, and Higher Education." USDA, Science and Education Administration. Misc. Publication Number 1405. January 1981.

Table 4. Biomass research, Extension, and demonstration programs authorized by Title II of the Synfuels Bill.

Category	Funds authorized
Model demonstration biomass energy facilites: Authorized establishment of not more than 10 facilities, in cooperation with the States or Federal agencies, to exhibit the most advanced technology for producing biomass energy.	$5 million for each FY 1981 through 1984
Biomass energy research and demonstration projects: Amended Title XIV of the 1977 Farm Bill to include alcohol and other forms of biomass energy as substitutes for petroleum and natural gas. Biomass is defined as any organic matter available on a renewable basis, including agricultural crops and agricultural wastes and residues, wood and wood wastes and residues, and animal wastes.	$12 million for research for FY 1981 through 1984
Biomass energy education and technical assistance programs: Amended Title XIV of 1977 Farm Bill to provide for educational programs on biomass production and use for producers of agricultural commodities, wood, and wood products, and to authorize the State Director of cooperative extension in each State to develop a single, comprehensive, and coordinated plan which includes biomass energy educational and technical assistance programs.	$10 million for each FY 1981 through 1984

DOE has been assigned lead agency responsibility for all Federal energy programs. Federal funding for SEA's energy programs is limited to those technical areas defined in the 1977 Farm Bill and the Synfuels Bill and to technical areas that can be defended to DOE, OMB, and Congress as being oriented toward agriculture, rural households, or rural communities and that can appropriately and more economically be conducted and managed by SEA than by any other Federal agency.

TRAINING AND EDUCATIONAL PROGRAMS

If high-priority, agriculturally-related energy problems are to be adequately addressed within the necessary time frame, the number of highly trained personnel available to industry, Government agencies (local, State, Federal), research organizations, and universities must be increased. Educational

programs (curricula) in agriculture that already deal in some way with energy-related issues must increase the emphasis on such issues. Some interdisciplinary programs must be developed. Programs that will help agriculturists, engineers, economists, home economists, and community developers to understand energy issues and to implement developing technologies and revised management systems must be increased. The rate at which education is producing highly trained scientists to conduct research, demonstration, and Extension programs must be accelerated. Additional funds are critically needed to provide the impetus for making necessary program changes quickly because the training of professionals requires 4 to 10 years.

During the next 5 years, Colleges of Agriculture in the United States should graduate an estimated 2,650 agriculturists whose programs have emphasized energy. Among those 2,650 graduates, 400 should be at the Ph.D. level, 1,000 at the M.S. level, and 1,250 at the B.S. level. That number of graduates is required to meet the needs in industry, State and local government agencies (such as State energy offices), Energy Extension Services (EES), CES, Federal and State research organizations, and university faculties. This estimated number is conservative but does indicate the magnitude of the problem.[4/]

ENERGY PROGRAMS UNDER CONSIDERATION

SEA now conducts or manages DOE-funded programs on agricultural applications of solar and wind energy, as well as essentially all federally supported research on on-farm energy systems and on the selection, screening, genetic improvement, and harvesting of energy crops for fuel alcohol, vegetable oils as diesel fuel extenders or substitutes, and other biomass products. Both SEA and DOE conduct research on alcohol and other biomass conversion processes.

This analysis of energy capabilities and opportunities deals with programs for which conduct or management by SEA is considered appropriate. SAES, Extension, and SEA laboratories may conduct energy programs with funds from other sources, including other Federal agencies, or they may be called to help with programs other than those listed.

The following energy program areas illustrate those for which the facilities and expertise of SEA and its cooperators will be most needed:

- Conservation and use of energy in production agriculture (e.g., tillage, fertilizer use, irrigation efficiency, and biological nitrogen fixation).

- Alternative energy sources in agricultural production (e.g., solar, wind, ethyl and methyl alcohols, and vegetable oils).

4/ For additional information, see "Graduates of Higher Education in the Food and Agricultural Sciences: An Analysis of Supply/Demand Relationships." Vol. I--Agriculture, Natural Resources, and Veterinary Medicine, by Coulter, K. Jane and Marge Stanton. SEA, USDA Misc. Pub. 1385. July 1980.

- Selection, genetic improvement, production, and harvesting of biomass for fuels, hydrocarbons, and petrochemical substitutes.

- Environmental impacts of biomass production for energy (e.g., effects of crop residue removal on long-term crop productivity and soil erosion).

- Agricultural utilization of byproducts from energy production (e.g., feeding of stillage and residues from fermentation processes to livestock and agricultural uses of waste heat from power generation).

- Energy education through programs of the 4-H and FFA.

- Energy conservation research in food processing, storage, and distribution.

- Woodlot management for the production of wood as an energy crop.

- Solar and wind energy conversion equipment intended for farm and rural application.

- Basic research on fermentation and distillation processes for commercial alcohol fuel systems.

- Automotive- and tractor-engine testing of alcohol fuel, alcohol-gasoline mixtures, and vegetable oils as diesel fuel extenders or substitutes.

- Thermal processing of biomass into low-Btu gas, condensate oils, and other energy products.

- Solar power, solar refrigeration, photovoltaic applications, and other technologies useful to agriculture.

- Equipment for utilization of biomass in production of commercial electric energy.

- Energy conservation in family living, household operation, recreation, entertainment, and transportation.

- Education for families and youth to help them make adjustments toward a less energy-intensive lifestyle.

- Development of alternative energy sources and evaluation of their potential use in the rural residential sector.

- Solar heating for rural homes and small communities—applied research and demonstration.

- Innovative house plans that are more energy efficient and cost effective.

- Technical assistance to local governments to bring about more efficient energy use in rural community facilities and services.

- Technical assistance to rural communities and local governments for the formulation of public policy involving energy needs, costs, and alternatives.

Specific plans should be developed to implement or strengthen most of these program areas. Such plans should include the present status of each program, available funding, and required resources for optimum results.

It is critically important to energy conservation/management policy and programs—and to the welfare of the Nation and its citizens—for all Agency components and units to work in harmony to effect maximum results. This need applies to research, extension, education (teaching), demonstration projects and to the development and distribution of timely and practical information.

II. NEEDS, OPPORTUNITIES, AND IMPACTS

U.S. ENERGY OBJECTIVES

National energy objectives have been articulated in many laws and policy statements. They can be summarized as follows for agriculture:

- To reduce dependence on foreign oil and to minimize the effects of supply disruptions through prudent conservation measures.

- To implement programs and policies that encourage domestic energy production and its efficient use, without serious inflationary impact.

- To develop inexhaustible energy sources for sustained economic growth through the next century.

- To use all energy sources in ways that do not endanger the environment and the health or safety of our citizens.

GOALS OF USDA/SEA ENERGY PROGRAM

The primary goal of the USDA/SEA energy program is to help meet the overall energy needs of the U.S. food and agriculture system and of rural America by developing knowledge and techniques for

- Efficient energy management and conservation in all aspects of agriculture.

- Development of alternative energy sources from agriculture without adversely affecting natural resources and the environment.

Recommended programs and specific levels of support for efficient energy management, conservation, development of alternative renewable energy sources (e.g. biomass, solar, wind, and waste-heat utilization), and integrated agricultural energy system opportunities are presented in later sections of this report. Needs for teaching and information systems are indicated also.

RECOMMENDATIONS FOR TEACHING, RESEARCH, EXTENSION, AND TECHNICAL INFORMATION SYSTEMS

An assured supply of energy for the U.S. food and agriculture system is clearly in the public interest and is a national priority. The Joint Council on Food and Agricultural Sciences identified energy as one of the areas for increased emphasis in the next five years.[5/] To ensure orderly progress toward its

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5/ "Areas of Emphasis in the Food and Agricultural Sciences for the Early 1980's." Joint Council on Food and Agricultural Sciences, March 1980.

energy goals, SEA's energy plan should be completed and widely publicized to facilitate understanding of the issues and to generate support.

The primary responsibilities of the publicly supported agricultural system are in the functional domains of teaching, research, extension, and technical information. Important program elements that need to be developed for each of the functional responsibilities of SEA are listed below.

Teaching

- Provide adequate personnel at various educational levels to meet energy program needs for university teaching, research, and extension; agribusiness; Federal and State governments; and vocational school instructors.

- Work with community colleges and vocational/technical schools to provide the technicians needed to apply energy conservation and management practices and adapt alternative energy systems to farm operations, agricultural processes, rural households, and farm buildings.

Research

- Establish a comprehensive data base on energy use in all aspects of the entire food system and in rural communities. Energy needs by month should be documented by enterprise, operation or end use, and energy type. This data base is essential for planning and evaluating energy conservation programs and for establishing emergency allocation programs in the event of energy shortages. The importance of timeliness in agricultural operations cannot be overemphasized, and meeting the energy needs of the food and agriculture system each month of the year is critical.[6/]

- Develop energy conservation goals and management guidelines for all components of the food system and rural living.

- Develop or adapt the technology for various renewable energy applications on farms, in rural households, and in communities.

- Develop an increased capability for anticipating and ameliorating adverse environmental impacts for energy development on agriculture.

- Investigate new crop and livestock systems that are more energy efficient than those presently used, including integrated systems that bring together a number of conservation and substitution technologies.

6/ For further information on energy use in agriculture, see "Energy and U.S. Agriculture: 1974 Data Base." FEA/USDA Vol. 1, 260 pp; Vol. II, 182 pp. September 1976.

- Investigate new crops, both annuals and perennials, that increase biomass yields or reduce energy requirements, or both. Include forest legumes, crops suitable for marginal soils and arid lands, and hydrocarbon and oil seed crops. Plant breeders may need to include new criteria in their programs.

- Make every effort to ensure that Title II of the Energy Security Act (P.L. 96-294) is funded and implemented.

- Develop more energy-efficient production, processing, transportation, and storage systems.

Extension

- Designate a full-time, energy Extension program coordinator in each State. This recommendation does not imply a new program area, but rather an interpretive and promotional role.

- Designate the transfer of energy technology and the efficient management of energy as priority programs within the CES. Integrate energy issues associated with the food and agriculture system with those of housing and family living. Given the current serious budgetary stresses, the energy education roles of CES and EES should be clearly defined. To serve the needs of existing clientele and of new audiences, the Extension system may have to develop new structural arrangements for reallocating existing resources and for securing new resources.

- Develop a comprehensive energy-outreach program that will include resource conservation, renewable alternatives, and energy management as related to the food and agriculture system, rural housing, family living, and rural communities and as related to adjustments that families and communities should make in order to maintain or improve their quality of life. A broad context for energy-related information is essential to make its wide distribution effective. Awareness and consideration of the environmental, economic, and social consequences of actions taken should be part of educational programs.

- Negotiate memoranda of understanding and other agreements that assign authority, responsibility, and funding for cooperative work with other Federal, State, and local entities in carrying out energy extension programs.

- Identify energy-related research needs and communicate those needs to SEA and SAES research personnel.

Technical Information Systems

Communication should be improved among researchers, administrators, teaching and Extension system personnel, and the public. TIS should put increase emphasis on energy by more aggressively searching out and catologing energy data and by developing more complete and useful information retrieval systems.

OPPORTUNITIES FOR ENERGY SAVINGS

Food Production and Processing

Almost 3 percent of the U.S. energy budget is used to produce raw agricultural commodities. Potential economies in energy use are possible through

- Improving the timeliness and effectiveness of fertilizer and pesticide applications while maintaining or increasing crop production.

- Improving nitrogen fixation of legumes to increase their usefulness in short- and long-term crop rotations and to decrease reliance of cropping systems on nitrogen fertilizers manufactured from natural gas.

- Matching tractor size to implement power requirements.

- Improving the efficiency of irrigation-water pumping, delivery, and use.

- Using minimum rather than conventional tillage practices.

- Adopting solar and low-temperature grain drying procedures.

- Properly insulating greenhouses and animal confinement facilities.

Research in these areas has made additional energy savings possible and will continue to do so.

Nearly 5 percent of the U.S. energy budget is used to prepare food for retail distribution. Analyses of energy used by the food processing industry suggest that significant energy savings are possible through the use of alternate management practices to recover process heat, more efficient equipment designs, and energy-saving packaging techniques. Increased use of electricity derived from indirect sources like coal, hydropower, or nuclear fission will decrease the heavy reliance (70-75 percent of the total energy usage) of the food industry on natural gas and petroleum-based fuels. Electric energy has an advantage because distribution facilities are available for immediate use, whether the power is generated by coal, nuclear, solar, wind, or methane sources. This advantage must be weighed against inherent generating and transmission losses. In many industries, food processing wastes can be used as fuel for direct-firing of boilers to reduce gas and oil consumption. Renewed efforts to communicate available information to food processors on possible ways to save energy are essential.

Home and Family

The household is a critical unit for bringing about reduced consumption and better utilization of energy. However, lack of specific information about the consequences of the energy consumption and management practices of households

has limited our ability to reduce home energy usage. Families must be provided accurate information on inefficient and wasteful energy practices and resource-conserving alternatives. Energy information is needed relative to food and fiber utilization, structure and location of housing, household management practices, and family living patterns.

In addition, most rural housing needs thorough weatherizing. New housing should be energy-efficient, and the use of solar energy for home heating, where feasible, should be emphasized. Human comfort can be maintained in a less energy-intensive environment by careful and knowledgeable choices of clothing and household textiles.

Rural Community

Energy savings in a rural community will be greatly influenced by its size, by the number and makeup of its businesses, by its community facilities and services, and by the attitudes of local government. The attitudes of citizens and local government on development, land use, zoning, siting, subdivision, waste disposal, and building codes could have significant long-term benefits to the community and its social, economic, and environmental well-being. Rural communities can reduce natural gas and petroleum use appreciably by adopting energy-efficient management and procurement practices, by adapting and utilizing renewable energy resources, and by developing long-range comprehensive energy plans.

Transportation of Agricultural Products

Energy savings in this category will depend on transportation changes adopted in other sectors of the economy. For example, the use of energy for transporting agricultural products can be reduced substantially by growing the products closer to areas of consumption and by increased use of railroads and barges instead of trucks. For some commodities, such as hay, the use of compact pellets instead of conventional bales may lead to energy savings in long-distance transport. Truck-routing and return-load coordination are other means of reducing transportation costs.

RENEWABLE RESOURCE TECHNOLOGIES

Appreciable amounts of crop, forest, animal, and food processing residues (in excess of those required for maintenance of soil fertility and erosion control) might serve as sources of alternative fuels. Such residues are currently used as sources of fuel for direct firing of boilers, for process heat, for production of oil and gas by pyrolysis, and for generation of methane gas from animal wastes. Basic and applied research on fermentation processes are needed to exploit the full potential of crop and animal residues.

Some crops produce oils that may be used as fuels or fuel extenders in diesel engines with moderate engine modifications. Research is needed to extract, process, and purify vegetable oils for use as fuels and to develop crop varieties and new crops with improved oil-producing capabilities.

The limitations of conventional conversion systems for producing alcohol or other liquid fuels from grain and crop residues have stimulated suggestions that crop materials may be genetically altered to improve their suitability for fermentation. For example, some mutations of corn have a higher proportion of sugar to starch in the endosperm of the grain. Theoretically, genetic engineering may improve the suitability of corn for fermentation. Useful genetic alterations in crop-residue composition may improve the efficiency with which biomass is converted to alternative fuels. Plant breeding programs are long-term, and the financial and personnel resources for such programs should be carefully considered. The potential impacts of alcohol production technologies on conventional grain and protein markets also must be evaluated. The feeding value of stillage and residues from oil-extraction processes should be determined, and holding systems for wet stillage should be developed.

APPLYING ENERGY SOLUTIONS TO AGRICULTURAL PROBLEMS

Many energy solutions can be applied more effectively in an agricultural setting than in an urban or industrial one. For example, farmers in the Corn Belt can effectively dry grain with air heated to only 50^{o} F by solar energy; continuous heating of the air is not necessary. Use of passive solar system for such applications would eliminate the need for thermal storage. Energy-saving opportunities also exist for such operations as irrigation pumping, environmental control for livestock, and integrated energy management for farmsteads. The agricultural system should take advantage of these special opportunities.

The safe and practical application of solar, wind, or biomass energy for on-farm production of electricity and for transfer of that electricity to existing power systems requires thorough research.

POTENTIAL IMPACTS

The total U.S. public will be affected adversely by any energy shortages or cost increases and beneficially by energy conservation or use of any developed technology for replacing fossil fuel energy with alternative forms of renewable or noncritical energy. Shortages of energy impact the entire food chain--from production through processing and distribution to final use by consumers. Groups affected most directly by SEA programs are farmers and producers, food processors, households, youth, and rural communities.

If farmers use anticipated technologies to produce energy from agricultural products, they can increase demand for those products and increase their net farm income. Crucial policy questions relating to competition for the use of agricultural products as food versus their use as a source of fuel can result. Effects of such policy decisions will be felt by our people and by countries that rely on our agricultural exports.

The family is a critical decision-making unit for bringing about solutions to the energy problem. The family shapes the future through its everyday decisions. Family decisions form a lifestyle and affect the broad decisions of society. Long-term considerations will include possible energy-saving innovations in housing designs, greater utilization of solar energy for heating and cooling, as well as possible changes in furnishings and equipment in the home, clothing practices, modes of transportation, communication systems, recreation, use of leisure time, community development, and job opportunities.

Reallocation or adjustments in the use of the family's financial resources may involve increased use of human time and energy instead of automation. Conservation practices will become more attractive as the cost of energy increases.

Funding for SEA energy research and Extension totalled $28.8 million in FY 1980. However, SEA energy programs must be greatly expanded if food and fiber needs are to be met and petroleum impacts reduced.

Specific suggestions and priorities for meeting program needs follow. These programs cover federally supported research in SEA and SAES, federally supported Extension work, and teaching programs. The funding levels that will be discussed include currently supported special energy projects and special energy extension projects administered entirely, or in part, by the Cooperative Extension Service in some States. They also include DOE pass-through funds such as the current solar, wind, and biomass fuel programs.

CONSERVATION AND MANAGEMENT

Agriculture and the Food System

For decades, efficient farm operators have practiced prudent management of farm machines, manpower, and farmstead systems. Highly sophisticated controls, such as microprocessors, require further study and application. Eventually, computerized management systems will be used to reduce peak electric loads on farmsteads and to provide energy-efficient performance of field machines and systems. When applicable, these controls will be integrated with the development of alternative, renewable energy resources.

The use of energy conserving solutions without concern for management decisions, especially those concerning the timing of operations, can result in reduced crop yields and, thus, reduced energy efficiency per unit of farm product. As microprocessor control begins to lend itself to complicated management techniques, its applicability or limitations, or both, will warrant early study. For crop irrigation, the use of such controls will conserve energy, as well as water and fertilizer. Microprocessors have great potential for use with crop drying and other crop-processing functions.

Efficient management of specialized equipment, such as electric crop-irrigation systems, is essential to assure optimum use of existing and future facilities for electricity generation and distribution. Although specialized operations vary among States, regionally coordinated studies can be implemented and conducted effectively with significant benefits to intermediate and long-range operations of both the agricultural and electrical industries. Appropriate use of small (3 to 10 horsepower), electric-powered equipment in the farmstead and home should be investigated.

An energy management technique that can be used to conserve dwindling oil and natural gas supplies is the substitution of one form of energy for another. For example, small electric motors might be used to power equipment used for feed grinding, feed processing, water pumping, and other stationary operations instead of large engines fueled by gasoline or diesel. Such applications of electricity have already contributed much to oil and natural gas conservation.

Solar and wind energy can and should be substituted for other energy forms when economically feasible. Although complete self-sufficiency of many farms is unlikely, the impact of integrating the output of renewable-energy production systems into farm operations (e.g., methane for providing peak power) requires early study and careful system development.

Priority programs for agriculture and the food system include

- Development and implementation of more efficient tillage and irrigation practices and fertilizer, pesticide, and herbicide application systems.

- Matching of power units with implements for most efficient fuel use.

- Proper matching of power units to the load in stationary farmstead operations, regardless of energy form used.

- Energy-management and safety education for both traditional and renewable-energy production systems.

- Education emphasizing energy policy, regulation, principles, and applications as they relate to resource management and resource conservation on the farm.

Family Living and Housing

Home economics research and Extension programs can make an important contribution to the solution of household, community, State, regional, and national energy problems. The expansion of research and education for families as energy consumers can have an immediate, favorable impact on energy use and can stimulate the use of renewable and alternative energy forms. Education programs can stimulate acceptance of energy-saving innovations in housing designs and household equipment that can change the national direction of related industries. Examination of current food consumption patterns will provide a base for reducing energy use in food systems.

Priority programs for family living and housing include

- Promotion of proper maintenance and prudent use of major home appliances.

- Development of improved technology for weatherization, insulation, and home-construction that will conserve energy.

- Promotion of family-directed conservation and utilization programs for energy and nonrenewable resources.

- Development of a data base on energy usage in rural areas.

- Establishment of family-housing demonstration projects in weatherizing, retrofitting, and landscape management.

- Provision of energy information on household practices related to selection and use of housing, appliances, household furnishings, and clothing, and selection and preparation of food.

- Development of financial-management education programs to help families cope with increasing energy prices.

- Establishment of family-housing demonstration projects in which solar--passive and active--is used as the energy source for home heating and cooling and in which various backup heating systems that burn wood and coal efficiently and safely are included.

- Establishment of effective linkages with the assistance programs provided by various agencies for low-income and elderly people.

- Development of plans for energy-efficient and solar-heated houses to meet the needs of rural families.

- Development of research and demonstration programs in cooperation with the building industry and with FmHA or other providers of assistance programs to help gain acceptance of innovative and more energy-efficient housing. Such programs can provide field experience for graduate students and training opportunities for Extension staff, planners, and builders of rural housing.

- Assessment of the safety and effectiveness of new energy conservation practices related to food and fiber use by families.

- Initiation of programs that help families cope with emergency situations caused by energy shortages or interruptions in energy supply.

- Initiation of programs that encourage families to participate in energy policy formation (e.g., transportation, recreation, marketing, tax structures, and subsidy programs).

Rural Communities

Communities use appreciably more energy than does the food and fiber system. They are responsible for policies that affect all sectors of society, and energy use in the community affects the food and fiber system, as well as the community as a whole. Therefore, community and rural development research and Extension programs can have immediate and long-term effects on the use of oil and natural gas.

Priority programs for rural communities include

- Formulation of comprehensive community energy plans.

- Development of cost-benefit analyses for the impacts of various management and conservation options on the sectors that will be affected by an energy plan.

- Development of cost-benefit analyses for impacts of energy substitutions and renewable energy resource options on the sectors that will be affected by an energy plan.

- Expansion of studies to include economic, social, and environmental impacts of a community energy plan.

- Assessment of legal implications of various energy options.

- Establishment of community demonstration projects on energy conservation, integrated energy management, renewable energy, and waste recovery options.

- Review and revision of planning, zoning, siting, subdivision, and building code regulations for efficiency, for use of renewable energy sources, and for substitution and conversion opportunities.

- Development of energy-efficient concepts and technologies for renovation of existing, and construction of new, community facilities.

- Evaluation of the energy efficiency of systems for distributing goods, and for transporting people.

ALTERNATIVE ENERGY SOURCES

Biomass and Biomass Energy

Title II of the Synfuels Bill defines "biomass" as any organic matter that is available on a renewable basis, including agricultural crops and agricultural wastes and residues, wood and wood wastes and residues, and animal wastes, except that the term does not include aquatic plants and municipal wastes. "Biomass energy" is defined as any gaseous, liquid, or solid-fuel product produced by the conversion of biomass and by energy or steam derived from the direct combustion of biomass for the generation of electricity, mechanical power, or process heat. For an excellent discussion on biomass-energy potential and policy implications, readers are referred to a recent report prepared by the Office of Technology Assessment.7/

7/ "Energy From Biological Processes," 1980. Office of Technology Assessment, U.S. Congress, OTA-E-124, 195 pp.

Production, Handling, and Processing

The biomass component of the SEA energy program can contribute directly to agriculture's fuel and energy needs and, perhaps, to other U.S. needs through production of raw materials from which gaseous, liquid, and solid fuels can be obtained. In addition, agriculture can provide feedstocks for manufacture of hydrocarbon products that are currently derived from petroleum or nonrenewable resources. Examples would be natural rubber, industrial oils, and agricultural chemicals.

Research is needed on both established and new crops. The breeding of established crops specifically for biomass would not be constrained by the quality requirements of the normal food market. For example, potatoes unacceptable in taste or appearance for food use by consumers often have a starch content 2.5 times that of edible potatoes and would be ideal for alcohol production. Crops bred solely for high starch content could produce alcohol yields significantly greater than alcohol yields for current food-crop varieties.

Oilseed crops of improved yield or fuel oil quality can be developed as well. Breeding programs, fertilizer needs, disease resistance, and agronomic practices should be fully explored for numerous promising crops so their full potential for providing biomass energy can be realized.

As new varieties of energy crops evolve from a screening program, good management practices for production, harvest, and storage must be developed. Even when established crops such as sugarbeets are grown specifically for energy, they can spoil if the processing capacity is inadequate.

Potential biomass energy crops must be studied from the processing standpoint. A major concern in alcohol production is the conversion of lignocellulose (either from residues or from cellulosic crops such as kenaf) to sugars for subsequent fermentation. Much needs to be learned about feed values, handling, storage, and utilization of the byproducts of fermentation. Little is known about the long-term stability of vegetable oil (including soybean or sunflower oil) used as diesel fuel extenders or substitutes. Questions exist regarding the amount of oil refining and modification needed and whether such processing should be done on the farm, in larger cooperatives, or in industrial facilities.

A major public concern is the current difficulty in obtaining sound and unbiased technical information. Numerous technical questions on alcohol fermentation, on vegetable oil refining for diesel fuel, and on biomass crops are "flooding" the SEA system. Current information on crop production, handling, and processing must be made available to the public. Demonstration projects are needed as new crops and processes become feasible. Already, opportunities are developing for combining several technologies to take advantage of energy-production alternatives. Feedback from users who have encountered specific problems should be channeled by Extension personnel to the research groups that can respond most capably to the needs.

Conversion Technologies

Combustion, gasification, and pyrolysis of crop and wood residue offer potential for energy development, but problems concerning air quality, fire hazards, and process residues must be addressed. Collection and handling systems for these biomass and fuel materials are critical, and such systems are not yet developed.

Extension needs regarding alcohol production from grain and other starch crops are great and will increase as problems arise in the operation of the current generation of on-farm stills. Low alcohol yields caused by problems with sanitation, pH, and temperature control are already evident. High water content, short storage life, and insufficient information on the nutrient value of distillers grains and liquid stillage restrict the utilization of these products as livestock feed. Although Extension specialists can solve some of these problems, others require further study.

The fossil energy required for alcohol production can be reduced, especially in small-scale operations, by utilizing crop residues. Heat exchangers can be used to transfer waste heat from cooling to heating operations. Vacuum stills show promise because they operate at lower temperatures and are safer than the stills now in use.

Farmers are particularly interested in using vegetable oil instead of alcohol as a substitute for diesel fuel because oil-expressing operations are less complex than fermentation and distillation processes. However, reports have surfaced that oxidized soybean oil has coagulated in the crankcase oil and threatened blockage of the lubricating system. Information on combustion characteristics of vegetable oils is urgently needed so mechanical failures and investment losses resulting from farmer experimentation can be prevented. Oil crops that can be grown on marginal land should be evaluated for specific geographic regions.

Procedures for biological production of methane are well documented, and such production should become cost effective as energy costs rise and the stringency of livestock waste-handling requirements increase. Research and development is needed on the generation of gas from crop residues. Such gas has considerable potential for stationary power applications and heating.

Agriculturally Produced Hydrocarbons

Crops such as guayule, jojoba, and crambe, although not an energy source per se, may be used as petrochemical substitutes. The United States currently imports an estimated $27.3 billion worth of agriculturally produced materials essential to industry in the production of rubber, plastics, adhesives, lubricants, synthetic fiber, and a host of other products. Crops such as these should be investigated for their potential in reducing the dependence of U.S. industry on imported agricultural materials for such production needs and in reducing industry's petroleum needs.

Solar and Wind Energy

The DOE has estimated that solar energy can supply 20 percent of the Nation's energy needs by the year 2000. Agriculture, which operates the largest solar energy collector via crops and trees (not included in the 20 percent), can use solar power for a portion of its energy requirement. Although inexhaustible and nonpolluting, solar energy is diffuse, intermittent, seasonal, and nonuniformly distributed. Therefore, to be useful, it must be collected from large areas and concentrated.

Research is needed on methods and equipment for collecting and utilizing solar energy for controlling plant and animal environments, crop drying and conditioning, heating and cooling rural residences, water heating, and on-farm processes. The potential for using combinations of active/passive solar energy systems appears high. However, cost-effective designs and construction material combinations must be developed. Some processes can probably be modified to use solar energy effectively without alternative backup systems; this possibility warrants examination.

Research and Extension activities related to solar energy utilization must be increased appreciably to meet existing energy goals. The solar program should be fully staffed (two researchers per State and an average of slightly more than one Extension specialist per State) for the period 1990-2000. An estimated $100,000 per Extension specialist includes funds for conducting demonstration programs.

Wind energy, the result of differential heating of the earth's surface, is considered to be a form of solar energy. Like the source that produces it, wind energy is variable and intermittent. Information on system design and effective use of wind energy is needed. Effective utilization of wind energy may involve changing production/processing practices or developing combinations of wind and either conventional or renewable backup energy systems. Research is necessary to integrate the system components. If excess power is converted into electricity, it can be sold to public utilities. Before the excess power can be marketed, however, many interface problems must be solved.

The wind program includes such activities as providing energy for irrigation pumping and other shaft-horsepower applications, converting wind energy to electricity for various farm uses, developing interface equipment required for connection to the public utility electrical grid system, and storing excess energy for later use. National wind-program efforts should peak about 1990, with at least 20 full-time researchers and 15 Extension specialists. By the year 2000, the needs should drop to 10 full-time researchers and 10 Extension specialists.

Although the contribution from solar and wind energy to the overall agricultural energy supply may be relatively small, in some regions these sources can be major energy contributors. Thus, solar and wind energy sources should be developed.

INTEGRATED AGRICULTURAL ENERGY SYSTEMS

Opportunities exist for combining several technologies to take advantage of energy-production alternatives. DOE has funded 12 energy-integrated demonstration farms. The objective is to illustrate how today's technologies can be combined into farming systems that will maintain production and profitability while using less petroleum and natural gas. Additional research and demonstration projects are justified and needed.

SETTING PRIORITIES

Clearly, research can aid in setting priorities. For instance, suppose we decide to set aside 10% of the agricultural farmland for liquid fuel production and to place marginal lands into production for this purpose. The effect on commodity prices, oil imports, wind and water erosion, processing capacity, exhaust emissions, and other side effects will require documentation and careful consideration. The question of central processing units versus separate energy farms is another example. Understanding the aggregate impact of the myriad of alternatives is vital.

Another issue in priority setting is the governmental (State and/or Federal) level at which decisions regarding programs must be made. Decisions on the proportion of effort to be devoted to alcohol research as opposed to the proportion devoted to vegetable oil research should be made at a relatively high national level. However, the choice as to which vegetable oils will be studied should be a regional, State, or local decision. Details at the project level, within broad guidelines, should be decided by the scientists involved and their immediate supervisors.

The arguments above relative to setting research priorities apply in principle to Extension priorities also. The criteria for timing, capability, and program balance must be addressed by the Extension groups most knowledgeable about the national, regional, and State needs and policies.

CRITERIA FOR ALLOCATION OF FUNDS

Allocation of research funds to specific programs should be based on the following criteria:

- National Need.-Projects directed toward broad national need and toward saving or replacing large amounts of energy should receive priority in national program planning.

- Urgency.-Rapidly rising oil prices and possible oil cutoffs require high priority for projects leading to replacement of imported oil in the short-term.

- Impact.-Economic, social, and environmental effects caused by a particular practice must be considered. Projects to study these effects deserve particular attention.

- Capability.-Successful programs depend on the availability of facilities and on expertise of the personnel that perform the work. Priority should be given to projects and programs that build on proven expertise and available facilities.

- Timing.-Programs critical to the successful execution or completion of other key programs should be given high priority.

- Program Balance.-Establishment of program priorities should include consideration of geographic balance, as well as subject-matter balance, although some imbalance should be tolerated to implement a badly needed "crash" program.

IV. RESEARCH AND EXTENSION SYSTEM

A comprehensive energy research, Extension, and teaching effort is needed to accomplish the goals of an agricultural energy plan based on the situations existing in various U.S. localities. SEA is highly qualified to undertake this effort. SEA has a broad Federal research base that includes both facilities and technical staff, a nationwide system for research program planning and coordination that encourages cooperation among the States and between State and Federal research partners, and an Extension system in place that enjoys a three-way working partnership that functions at the national, State and local levels. Overall research and Extension capabilities of SEA are enhanced by those Federal-State partnerships that were created by the Hatch and Smith-Lever Acts. SEA also has user advisory groups that function at all levels to assist with the development and implementation of plans and with resolving problems. Citizen involvement is encouraged.

WORKING STRUCTURE OF USDA

National Level

SEA has responsibility for the Federal component of the publicly supported agricultural research and technology transfer system. Its major units are Agricultural Research (conducts in-house research); Cooperative Research (administers Federal support to SAES's, 1890 land-grant Colleges and Tuskegee Institute); Extension (administers Federal support to State Cooperative Extension Services); Technical Information Systems; Human Nutrition; and Higher Education. SEA also has a Special Program (SP) unit which manages DOE pass-through funds and grants for energy programs. AR, CR, EXT, and SP have energy coordinators or staff specialists to handle energy programs.

The SP Program Manager for Energy coordinates pass-through funding from DOE and energy grants, serves as a contact with USDA agencies and Federal departments, develops budgetary support documents, coordinates staff studies on energy and provides the SEA Director with energy information, reviews and concurs in Congressional correspondence on energy, coordinates programs for the regional agricultural energy centers, and serves as the executive secretary of the SEA Energy Program Board. The Program Manager reports to the Assistant Director for Special Programs.

SEA energy staff specialists review federally supported energy programs; provide budgetary information; coordinate specific programs; serve on SEA and other energy teams, committees, and boards; provide contact with their unit representatives at the regional agricultural energy centers; and provide information on Federal energy programs and activities to their constituents. The present structure of SEA should enable it to carry out an expanded agricultural energy program.

Regional Level

Energy requirements for agricultural production and rural living vary among regions. Likewise, the climate and other factors result in production of different forms of renewable energy. For example, the potential for wind energy in the Southeast is not as great as the potential for biomass, whereas the converse is true in the High Plains. Consequently, a national agricultural energy program should include a limited number of regional research and technology transfer centers such as the two agricultural energy centers recently established by SEA and the four existing regional centers for rural development.

In addition to planning and conducting a research and technology transfer program, these centers provide feedback to other units of SEA for evaluation and future planning by obtaining input from the research user groups and individuals. Feedback from State universities with educational programs that often are conducted in cooperation with electric power suppliers, farm organizations, community colleges, and others, helps to target research efforts on real needs or problems.

State Level

A fundamental strength of the Nation's agricultural system is the close working relationship among research, Extension, and teaching staffs at the State level. This relationship facilitates rapid technology transfer to the ultimate user, immediate feedback of problems to researchers, and training of scientists.

Three major USDA agencies (SEA, FS, and ESS), 56 State agricultural experiment stations, 19 schools of forestry, 16 land-grant colleges of 1890, and the Tuskegee Institute conduct about 95 percent of this Nation's publicly supported agricultural research. These agencies historically have pooled ideas, manpower and facilities in coordinated attacks on problems that are State, regional, or national in scope.

The agricultural research system is responsive to long- and short-term State and local needs because of the Federal-State partnerships mandated in the Hatch Act of 1887. This Act provides for the distribution of research funds to the States on a formula basis to supplement funds provided by State legislatures and private industry. This continuous funding provides more stable assistance than do short-term grants. The current organization of the research and Extension system is adequate to develop, conduct, and evaluate agricultural energy research programs if sufficient funds are available. State agricultural experiment stations are interdisciplinary and can effectively address complex energy problems.

The CES plays an important role in synthesizing and transferring energy research results from public and private organizations to the county Extension agents. Extension staffs participate on statewide policy committees and follow policy developments to ensure early participation in program planning.

Technology transfer and identification of State energy problems are easily accomplished through the coordination research and Extension functions at land-grant universities.

Undergraduate and graduate instruction to train scientists and technicians for energy programs should be a primary responsibility of each State. Bankhead-Jones formula funds assist in the performance of this function, but the need for expertise is critical and grants and fellowships should be made available to institutions of higher learning to accelerate the training of technicians and scientists.

Local Level

The decentralization achieved by locating county Extension agents in each of the Nation's counties provides a proven means of disseminating research information effectively from public and private sources. The Cooperative Extension Service in each State receives county, State, and Federal funds and is the most publicly visible component of the research and Extension system. It has the demonstrated capability to integrate broad concerns, such as energy, into specific subject matter areas across all of agriculture. County Extension personnel must be familiar with the regulatory aspects of any agricultural energy plan, but CES personnel should not be responsible for regulatory actions because the CES must maintain an objective, educational role as its primary identity. Publicly funded "demonstration farms" or demonstrations on private farms should promote energy-conserving practices at the local level. The goals outlined in the report entitled "What Role of the Cooperative Extension Service in Energy Education?" should be fully implemented.8/

CAPABILITIES OF THE AGRICULTURAL RESEARCH AND DEMONSTRATION SYSTEM

The agricultural research and demonstration system has the capacity to encourage biomass production from agricultural and forest residues, on-farm biomass gasification or liquefaction, use of solar and wind energy for farms and rural homes, and energy conservation and management in homes, on farms, and in food industries. Two notable examples of achievement are the competitively priced solar collector and storage unit developed at Kansas State University that is being used in hog farrowing units all over the Midwest, and the USDA solar home designed at Clemson University (now in production by National Homes). Real energy savings available through these two programs over the next few years may well exceed the entire DOE/USDA pass-through investments in livestock housing, rural residence, and greenhouse programs. Also, recent data from Nebraska show a savings of $36 million annually in pumping costs through irrigation scheduling.

8/ "What Role of the Cooperative Extension Service in Energy Education?" A report of the ECOP Energy Task Force by the Technical Subcommittee on Energy. Gene McMurtry, Chairman, December 11, 1978.

INTERACTION WITH USDA AGENCIES

SEA's goals and programs for energy interact significantly with those of other USDA agencies. For example, research, Extension, and technical assistance programs in forestry are major activities in both SEA and the Forest Service. Because of these legislated, parallel activities within USDA, the programs of the two agencies are carefully coordinated. Joint planning of energy activities is similarly essential to avoid duplication and to assure coordinated and complementary program efforts.

The Joint Council on Food and Agricultural Sciences provides one mechanism for coordination and has activated an ad hoc energy subcommittee. Committee membership includes representatives from OSTP, FmHA, FS, ESS, and SEA. These agencies have energy coordinators, energy programs, and master plans.

Several action capabilities within SEA are needed. At the highest level, a system of regular, energy-activity reporting through OBPE to the Secretary's Office should be maintained. SEA and other involved USDA agencies must be able to provide management officials with accurate information on current programs, attainments, outstanding accomplishments, new-initiative recommendations, funding needs, program evaluations, background facts, and presentation materials. SEA must also work with other USDA agencies to develop energy action programs; to integrate budgets; to marshall field capabilities in research, Extension, and teaching; and to effectively conduct and coordinate energy initiatives. When appropriate, representatives of other USDA agencies should be added to the ad hoc energy subcommittee of the Joint Council on Food and Agricultural Sciences.

INTERACTION WITH UNITS OUTSIDE USDA

Energy concerns are common to Federal departments other than USDA. Organizational mechanisms are needed for interaction with external energy activities, to learn from them, to avoid duplication, and to achieve synergistic cooperation and coordination. Several mechanisms (e.g., MOU's with DOE, EPA and AID; interactions with GAO, OMB, and various congressional oversight committees) facilitate external coordination for SEA energy programs. SEA's Program Manager for Energy will assess needs for interagency coordination on a continuing basis and make recommendations to the SEA Assistant Director for Special Programs. SEA should participate in interagency, interdepartmental, and international programs to further national energy goals and to enhance all SEA and USDA programs. The Federal Subcommittee on Food and Renewable Resources, chaired by the Director of SEA, should be a useful forum for interactions with DOE, NSF, EPA, TVA, and other Federal departments and agencies.

AGENCY IDENTITY

The foundation of the U.S. agricultural research, Extension, and teaching system was laid decades ago. Research (searching for new knowledge), Extension (delivering improved technology), and teaching (developing well-trained professionals) have served America well. Everyone has benefited at a very modest cost. The record indicates that USDA and SEA, along with State partnership, can provide the research, educational tools and mechanisms, and manpower needed to expeditiously study and report on energy issues related to food production, processing, preservation, transportation, and distribution. The USDA is also capable of other energy initiatives that affect the quality of life in rural America.

Programs to which USDA can contribute include, but are not limited to,

- Agricultural applications of solar energy.

- Wind energy for farm and rural applications.

- Agricultural biomass.

- Small-scale alcohol-fuel production systems.

- Interactions between food and fuel supplies and needs.

- Energy conservation and management (home, farm, and rural community systems).

- Energy substitution (e.g., electric and biomass energy for petroleum and natural gas).

- Alternative energy systems as they affect energy demands and supplies.

- Energy technology delivery systems.

- Energy education for manpower training.

- Amelioration of consequences of energy development on crop production, rural living, and rural communities.

- Energy demonstration farms.

V. RESOURCES

CURRENT FUNDING SITUATION

The U.S. system of funding public-oriented research, Extension, and higher education activities in the food and agricultural sciences has significantly benefited all consumers of food and fiber, as well as farmers, the associated "in-between" food-system sectors, and rural America. Increasing agricultural productivity over the past 75 years, largely due to a system of coordinated, task-oriented efforts that usually have interfaced directly with the beneficiaries, has led to rates of return unequaled by those from any normal investment in the private sector. This system contributed greatly to the agricultural growth rate of from 1.7 to 2.7 percent per annum during the past 50 years.[9/] In many States, the private sector has contributed to the funding of agricultural research for decades.

Unfortunately, research support for many areas of agriculture, in terms of constant dollars at Federal, State, and county levels, has decreased in the face of other critical concerns. A study by Eddleman[10/] indicated that agricultural productivity will decline markedly unless major technological breakthroughs occur or significant additional investments are made at all levels of the system. Energy programs must not be developed at the expense of other agricultural programs that contribute to the many and varied needs of agriculture.

The education, research, and Extension components of the agricultural system represent a unique, dynamic, and productive segment of the total American system. Present limitations to greater, more significant contributions are uncertain funding (amount and continuity), insufficient numbers of trained personnel, and inadequate facilities. The strengthening of the proven Federal-State partnership for agricultural education, research, and Extension and the direction of its effort toward two primary concerns of the Nation--food and energy--can be of much mutual benefit to all segments of the system and to all food consumers.

Present funding mechanisms for publicly managed agricultural research activities (ongoing research, including energy) are listed in Table 5. Brief descriptions relative to the management and utilization of these funds for conducting of research within a typical university system and within units of USDA are also included. Energy resources for FY 1980 are listed by fund type in Table 6. Federal appropriations to USDA amounted to $28.8 million, Federal funds to USDA from other agencies via grants and pass-through amounted to $4.4 million, and State appropriations amounted to $20.5 million (see Table 3).

9/ "Areas of Emphasis in the Food and Agricultural Sciences for the Early 1980's." Joint Council on Food and Agricultural Sciences Report, March 1980.

10/ Eddleman, B.R. "Research and Education Support for Food and Agriculture in the National Interest." Unpublished report prepared in support of the FY 1982 budget request for SEA. B. R. Eddleman is Director of the IR-6 Program, National and Regional Planning, Evaluation, Analysis, and Coordination.

Table 5. Current funding mechanisms for publicly managed agricultural energy activities

Fund type	Source	Description and utilization
Formula	Hatch Smith-Lever McIntire-Stennis Bankhead Jones	Funding fluctuates somewhat but provides for program continuity & base support for regular staff & for "planned" support personnel. (Earmarked funds for specific energy research/Extension/teaching efforts should be seriously considered.)
State appropriations	State legislatures	Base funding for regular staff personnel is provided. Good for professionals with appointments split between teaching and research.
Special grants	SEA-CR	Primary competition is among State researchers. Good supplement to formula funds. Limited scientist time used for obtaining grants. Short-term funding not conducive to long-range efforts.
Competitive grants	DOE EPA	Grantsmanship & time requirements can be high for overall results achieved. If not on at least a 3-yr basis, staffing of University groups can be difficult. This often leads to short-term funding of groups in the private sector who, in turn, recruit University personnel. Opportunity for multidisciplinary team effort is good.
Direct Grants, contracts, and cooperative agreements	USDA-SEA NSF DOE Other	Supplemental funding for staff is provided. Similar staffing problems as for competitive grants. Funding should be for 3-yrs or longer for good personnel/project team match.
Industry support	Local, State, and national industry units	Research thrust is aimed at tasks of mutual interest to sponsor & researcher. Amount of time & funds are negotiable, but grants should be for 3-yrs or longer. Can serve as seed money to expand project.
Commodity group support	State or national commodity groups	Same as "Industry support."
Pass-through	DOE EPA	Project activities and amounts are determined by Federal agency other than USDA. Often managed by USDA personnel if staffing is attainable. USDA may be unable to use all expertise in conducting studies.
USDA in-house appropriations	Congressional appropriations	USDA has control over all funds, project planning, management, & dissemination of information obtained. Manpower & project scope is limited by appropriations. Funds are received on a yearly basis.

Table 6. SEA's energy resources by fund type-FY 1980

Fund type	million dollars
Formula:	
Research	1.4
Extension	10.0
Special grants	1.9
Competitive grants	0.5
State appropriations	
Research	7.0
Extension	13.5
Direct grants and contracts	Unknown
Industry support	Unknown
Commodity group support	Unknown
Pass-through	4.4
USDA appropriations for in-house research	15.0

MANPOWER DEVELOPMENT AND TRAINING

An especially critical element for effective, ongoing research in the agricultural energy field is the availability of experienced, agricultural, energy-oriented professionals to direct and manage specific projects in their area of expertise. During the next 5 years, some lateral movement or redirection of resources can be effected for the initiation of intermediate and long-term projects. However, additional qualified staff are needed at all levels to conduct new interdisciplinary research and Extension programs in agricultural energy. Base support, such as an energy fellowship program, is essential to help train and develop energy-oriented scientists to conduct effective and efficient research, education, and Extension activities in the intermediate term (5-10 years). Part of the Nation's dilemma is a shortage of qualified, agricultural energy experts to fill key positions. Research, education, and Extension personnel in agricultural engineering and other energy-related areas already carry excessive work loads at many State universities due to

- Reductions in numbers of graduate students; the spread between the salary of a B.S. graduate and a Ph.D. graduate can be as little as $1,500/yr.

- Heavy teaching loads by professionals; attrition, State limitations, and industrial opportunities have reduced staff numbers resulting in increased student numbers per teacher in the classroom.

- Inadequate facilities for effective and efficient research in the energy area.

With appropriate planning, reasonable lead time, and prudent funding (often a combination of Federal, State, and industry or commodity group actions), the limitations listed above can be overcome to fully utilize the characteristics and capabilities of all components of the agricultural research and Extension system.

RESOURCE NEEDS

Recommended Funding Levels and Justification

The 2.9 percent of U.S. energy that is consumed by production agriculture is equivalent of about 1 million barrels of oil per day. Petroleum fuel provides an estimated 80 percent of this energy, which amounts to about 800,000 barrels of oil per day (an amount equal to approximately one-tenth of U.S. imports in 1979). Based on the current price of imported oil, liquid fuel for production agriculture has a value of about $9 billion per year (or $25 million per day). The total cost to the United States in terms of inflation, lost jobs, and balance of payments deficits is incalculable.

If 1 percent of the value of liquid fuel for production agriculture were designated for research and education on management and conservation, $90 million would be available annually--a small amount considering the need for, and impact of, energy independence in food and fiber production. The entire food system uses about 16.5 percent (see Fig. 1) of the Nation's energy. By the same logic as above, 1 percent of the value of energy for the entire food system is about $500 million annually. These levels of support, over a period of years, would ensure the development of methods and equipment for providing the fuel to enable one grower to produce food for at least 73 other Americans, in addition to agricultural commodities for export, without relying on increasingly expensive and uncertain foreign petroleum supplies. In addition, the whole food chain would become more efficient from planting through harvest to the ultimate consumer.

Recommended levels of future Federal funding for SEA energy programs are presented in Table 7 along with comparable funding levels for FY 1980. The intense interest in alcohol fuels and other biomass energy requires substantial increases for both research and Extension. For FY's 1981-1984, Title II of the Synfuels Bill authorized $12 million per year for biomass energy research and demonstrations projects and $10 million per year for biomass energy education and technical assistance programs. However, because of the great need for information relative to biomass production, annual funding levels of $29.2 million for research and $10.5 million for Extension are the recommended minimums[11/] for biomass energy projects in the near term. These funding

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11/ All funding requirements are expressed in 1980 dollars. The impact of inflation must be added.

levels should be achieved as soon as possible. The increase would provide research and Extension staff in each State, special energy grants, and expanded research at Federal laboratories. Annual increases of 10 percent per year above the amount needed to account for inflation are recommended.

Recommended Federal funding levels for SEA energy programs for the near-term (1981-85), intermediate-term (1986-1990), and long-term (1991-2000) are summarized in Table 7 in constant 1980 dollars (Federal pass-through funds are included). A more detailed breakdown of the funding needs for energy conservation and management in family living and housing is given in Table 8, and funding needs for developing solar and wind energy are shown in Table 9.

In order for Colleges of Agriculture to graduate 2,650 energy-oriented agriculturists and engineers during the next five years, programs in higher education must be strengthened. Grants of about $100,000 to $200,000 per State should be provided on a competitive basis to support increased energy emphasis in undergraduate programs. These funds would support such things as

- Developing and equipping laboratories in which technology related to energy conservation and conversion can be taught.

- Covering program costs for developing interdisciplinary offerings.

- Developing agricultural energy centers to provide supporting resources, services, and personnel to work with and advise faculty on energy matters that should be included in existing course work.

- Developing energy internship programs to allow students to work in selected industries and Government agencies as part of their educational program.

- Creating other innovative program proposals that will enhance the rate at which agriculturists can be prepared to deal with energy problems.

Recommended funding levels to support Higher Education in the near-, intermediate-, and long-term are summarized in Table 10. The primary needs in graduate education are support for graduate student stipends, some limited research-support funds, and some faculty release time for supervision of student programs. University faculties have the necessary expertise to develop these programs and can do so at an accelerated rate if resources are provided. Graduate fellowships are needed to attract top-quality students into energy-related programs to prepare them for research, Extension, and teaching careers. The average financial support figures used for developing the 1981-85 costs were $20,000 per year for M.S. candidates and $30,000 per year for Ph.D. candidates. The total level of funding requested for graduate education ($6.4 million) would not support the programs to the extent needed to produce the estimated number of graduates needed. However, this amount would provide an adequate base, and universities could provide the remainder. The challenge is clear—we must develop programs to train the professionals that will be needed to address the major agricultural energy issues of the future.

Table 7. Recommended funding for SEA energy programs

Program Categories	Annual budget, million 1980 dollars			
	1980	Near-term 1981-1985	Intermediate 1986-1990	Long-term 1991-2000
Research:				
Conservation and management:				
Agriculture and the food system	11.1 1/	12.5	15.0	17.5
Family living and housing	0.0	5.5	15.5	15.0
Alternative energy sources:				
Biomass	7.2	29.2	56.0	122.0
Solar/wind	3.8 2/	6.5	9.5	11.0
Extension:				
Conservation and management:				
Agriculture and the food system	5.4	6.5	8.0	9.1
Family living and housing	3.2	20.5	35.5	42.0
Alternative energy sources:				
Biomass	0.5	10.5	20.5	43.9
Solar and wind	2.0 3/	4.3	6.5	7.0
Teaching	0.0	11.4	12.5	12.5
Total	33.2	106.9	179.0	280.0

1/ Includes $0.3 million pass-through from Department of Energy and $0.4 million pass-through from Environmental Protection Agency.
2/ Includes $2.6 million pass-through from Department of Energy.
3/ Includes $1.1 million pass-through from Department of Energy.

Long-term vs. Short-term Support

Short-term projects (a year or less) have been a real problem in agricultural energy research. Once a proposal is written, approval is often granted after the proposed effective date of funding. Then personnel are recruited, equipment ordered, work started, and progress reports written. The timing for setting up the necessary hardware for experiments is often a problem when the project is seasonal; e.g., solar grain drying. The next year's proposal may be due before preliminary results of the present year's work have been obtained. Consequently, considerably more is normally accomplished per dollar expended during the second and third years of a project than during the first year.

Table 8. Recommended funding for energy conservation and management in family living and housing

Program categories	Annual budget, million 1980 dollars			
	1980	Near-term 1981-1985	Intermediate 1986-1990	Long-term 1991-2000
Housing and equipment:				
Research	-	3.0	8.0	8.5
Extension	-	10.0	18.0	22.0
Lifestyle:				
Research	-	1.0	3.0	3.0
Extension	3.2	5.0	12.0	12.0
Public policy and community:				
Research	-	1.0	3.0	3.0
Extension	-	5.0	5.0	7.0
Data base and evaluation:				
Research	-	0.5	1.0	1.0
Extension	-	0.5	0.5	0.5
Total	3.2	26.0	50.0	57.0

Table 9. Recommended funding for developing solar and wind energy

Program categories	Annual budget, million 1980 dollars			
	1980	Near-term 1981-1984	Intermediate 1985-1990	Long-Term 1991-2000
Solar:				
Research	3.0	5.0	7.5	10.0
Extension	1.7	3.5	5.0	6.0
Wind:				
Research	0.8	1.5	2.0	1.0
Extension	0.3	0.8	1.5	1.0
Total	5.8	10.8	16.0	18.0

Table 10. Recommended funding for higher education

Program levels	Annual budget, million 1980 dollars			
	1980	Near-term 1981-1985	Intermediate 1986-1990	Long-Term 1991-2000
Bachelor	0.0	5.0	5.5	4.5
Master	0.0	4.0	4.4	5.0
Doctor	0.0	2.4	2.6	3.0
Total	0.0	11.3	12.5	12.5

Recommended Funding Patterns

The following considerations and actions are essential for full utilization of the U.S. agricultural research and Extension system to solve energy problems.

- Research and Extension support should be provided to encourage and effect program planning for a minimum of 3 years (preferably 5 years). Formula funding and State appropriations for continuity of planning and support should receive top priority. Earmarking of formula funding for energy research should be considered. Mandatory reporting concepts can be effected as necessary.

- The stability provided by formula funding allows engineers and scientists to seek additional financial support from industry and commodity groups for appropriate energy projects. Formula funds not only broaden the funding base, but also place the agricultural energy research/educational system and its results within easy access of users, enhancing the impact of the Extension delivery system. Interactions of industry and commodity groups provide an additional support base for legislative actions at State and National levels.

- When granted on a 3-year term or longer, competitive grants and contracts serve as an excellent basis for manpower training and development. They are also beneficial in conducting high-priority research and Extension programs that are designated for a specific goal. These grants should generally provide supplemental funding to related ongoing projects directed by senior personnel with limited base funding. A balance should be maintained among in-house research (AR), university research (CR), and educational programs.

Facilities and Equipment[12/]

Investing in necessary additional facilities and equipment at locations where a critical mass of interdisciplinary professionals and support staff already exists will return higher dividends than allocating funds to organizations that must recruit or relocate staff. The agricultural research system, developed and perfected over many decades, already has a functioning staff in place.

12/ For further details, see "Facilities for Food and Agricultural Research." Report to the Secretary of Agriculture by the Joint Council on Food and Agricultural Sciences, March 1979.

VI. EVALUATION

Evaluation is not only critical to program management, but also is increasingly required to justify continued or additional public funding. The evaluation effort for energy-related activities deserves special attention and specific resource commitment, as denial of requests for mission-oriented energy funds is likely unless positive results can be demonstrated. Therefore, the purpose of evaluation should be to determine the merit of new projects and techniques and to provide the basis for improved resource decisions in the future.

RESEARCH EVALUATION

Some of the structural characteristics of the agricultural research system are critical in determining appropriate evaluation. The in-house research structure tends to be line-agency oriented. In contrast, the CR structure has traditionally involved many organizations (SAES, land-grant colleges and universities, Tuskegee Institute, and McIntire-Stennis) and different funding vehicles (e.g., formula funds and grants). In-house research is usually well-defined and highly consistent in terms of mission definition, funding, and reported work, while CR-funded research involves extensive discretion and goal setting by joint Federal, State, and local entities. Energy research often comprises an important part of research projects on other topics and is not likely to be explicitly identified. Despite all the complexities of classifying energy research, a system that will track in-house (AR) and CR efforts on a timely basis is needed.

SEA and the USDA must work more actively to overcome some of the information shortages evident in the recent past. Although some strides have been made toward providing responsive and comprehensive information to the public and the county Extension agents, as well as to researchers, the provision of such information must be accelerated. Needed areas of information transfer are

- Improved access to bibliographic records of research and other work being performed in the United States and elsewhere.

- Compilation of energy-related data files to be published as state-of-the-art reports for wide dissemination.

- Assembly of concrete research data, in interactive terminals, for ready manipulation by field, industry, and research personnel in agriculture.

- Continued compilation, updating, and publication of energy information.

- Assembly of a set of state-of-the-art reports for wide use.

- Mechanisms for increasing the speed of technology transfer for rural and small-farm activities.

These areas of information transfer must be actively supported with consistent and long-term funding if SEA is to move the entire agricultural community in the same direction in a short time.

EXTENSION EVALUATION

Extension programs are structured as truly cooperative efforts among Federal, State, and local governments. Local outreach programs focus evaluation on clients rather than on the resources committed. The clients or ultimate users can, therefore, exercise substantial influence over program content.

User activity, response, or investment resulting directly from Extension programs should be identified and evaluated. The Cooperative Extension System is developing instruments for use by field personnel in documenting changes in energy practices that result from Extension programs. Such information, when applied nationally to energy Extension activities, will greatly assist in evaluating program effects at the user level. One evaluation approach might be to use private investments in energy conservation and in alternative technologies and fuels as a means of evaluating program effects. Regardless of the unit of measure applied, program impacts will be difficult to assess precisely.

In addition, evaluations of energy-saving investment should be initiated in States or counties where important energy technologies are being adopted. Extension should provide one or more specialists in energy-investment evaluation to conduct pilot studies and to measure the application of research and Extension results by users. Even where technologies are now only marginally economic, these findings would provide valuable guidance for future programs.

USE OF TECHNICAL INFORMATION SYSTEMS FOR EVALUATING ENERGY PROGRAMS

TIS could help to substantially improve the effectiveness of CRIS by reducing the time lag for entering resource data, ensuring that energy-sorting categories are used, and assuring that all research classifications are complete and accurate. Implementation of the TIS evaluation procedure would require abstracts of all SEA reports or publications. These abstracts are essential for comparing results obtained from the agricultural research and Extension system with results from other federally funded energy programs. The competition for funds and the nature of energy-related activities require the added reporting effort.

Extension should adopt a continuing user-oriented evaluation system, with the pilot program initiated by TIS and EES as a model. A limited number of highly visible program areas could be assessed, such as home energy audit, alcohol production, and thermal processing of biomass. Care should be exercised to ensure that the reporting interval corresponds to the cycle of the program being assessed. Some improvement is needed in problem assessment and problem identification for research based on Extension-clientele contact. Analyses of annual plans of work might begin to provide such information.

EVALUATION OF OVERALL PROGRAM ACCOMPLISHMENT

Evaluation should be an integral part of planning to ensure that appropriate data are collected and assembled to satisfy the needs of the project or program. Upon completion and adoption of a comprehensive energy plan for SEA, the evaluation process should be designed to determine the effectiveness achieved in pursuing the plan. Accomplishments in each category of research and technology transfer should be clearly measured and documented for assistance to management in determining adequacy of performance and in modifying future program phases.

Reports on SEA research and Extension activities in energy would form the main source of data for this evaluation process. The recovery of project results through automated data processing will make possible the comparison of achievements in each energy category. The evaluation report should indicate the adequacy of progress in each targeted activity of the plan. Criteria for judging project results would include number and quality of publications, success in transfer of technology through the Cooperative Extension System, acceptance of results achieved through farm and related industry investments, and the adoption of techniques developed for energy conservation and substitution.

LIST OF ABBREVIATIONS

AID	Agency for International Development
AR	Agricultural Research (USDA/SEA) *Agricultural Research Service (USDA)
CES	Cooperative Extension System (Federal, State, and county)
CR	Cooperative Research (USDA/SEA) *Cooperative State Research Service (USDA)
CRIS	Current Research Information System
DOE	Department of Energy
ECOP	Extension Committee on Organization and Policy
EES	Energy Extension Service (DOE)
EPA	Environmental Protection Agency
ESS	Economics and Statistics Service (USDA) *Economics Research Service (USDA) and Statistical Reporting Service (USDA)
ERDA	Energy Research and Development Administration
EXT	Extension (USDA/SEA) *Extension Service (USDA)
FEA	Federal Energy Administration
FFA	Future Farmers of America
FmHA	Farmers Home Administration (USDA)
FS	Forest Service (USDA)
GAO	Government Accounting Office
HE	Higher Education (USDA/SEA) *Higher Education (USDA)
HN	Human Nutrition (USDA/SEA) *Human Nutrition Research (USDA)
MOU	Memorandum of Understanding
NAEC	Northern Agricultural Energy Center (USDA/SEA) *Northern Agricultural Energy Center (USDA/ARS)
NASULGC	National Association of State Universities and Land Grant Colleges
NFS	National Science Foundation
OBPE	Office of Budget, Planning, and Evaluation (USDA)
OMB	Office of Management and Budget
OSTP	Office of Science and Technology Policy
SAEC	Southern Agricultural Energy Center (USDA/SEA) *Southern Agricultural Energy Center (USDA/ARS)
SAES	State Agricultural Experiment Station
SEA	Science and Education Administration (USDA) *Science and Education (USDA)
SP	Special Programs (USDA/SEA) *Coordination through Science and Education (USDA)
TIS	Technical Information Systems (USDA/SEA) *National Agricultural Library (USDA)
TVA	Tennessee Valley Authority
USDA	U.S. Department of Agriculture

*Agency designations following reorganization announced June 17, 1981.

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